AFSC-TDR-63-2

NATURAL ENVIRONMENTAL DATA

and

SUPPORT REQUIREMENTS

TECHNICAL DOCUMENTARY REPORT NO. AFSC-TDR-63-2

January 1963

Office of the Staff Meteorologist
Headquarters, Air Force Systems Command
Andrews Air Force Base, Washington 25, D.C.

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FOREWORD

Technical information in the meteorological-geophysical discipline is required in all phases (study, development, test and evaluation) of systems acquisition. Air Force Systems Command systems divisions and test centers have expressed their most pressing natural environmental data support requirements. This report summarizes these statements of requirements from:

Aeronautical Systems Division (ASD)

Ballistic Systems Division (BSD)

Electronic Systems Division (ESD)

Space Systems Division (SSD)

Air Force Flight Test Center (AFFTC)

Air Force Missile Test Center (AFMTC)

Air Force Special Weapons Center (AFSWC)

Air Proving Ground Center (APGC)

ABSTRACT

This report summarizes a one time survey, made at the request of Headquarters USAF, to identify the Air Force Systems Command requirements for natural environmental data and support. A collection of specific requirements, expressed by AFSC divisions and centers, follows each requirements summary section.

PUBLICATIONS REVIEW

This report has been reviewed and is approved for publication.

FOR THE COMMANDER

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LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
AFCRL	Air Force Cambridge Research Laboratories
AFFTC	Air Force Flight Test Center
AFMTC	Air Force Missile Test Center
AFSC	Air Force Systems Command
AFSWC	Air Force Special Weapons Center
APGC	Air Proving Ground Center
ASD	Aeronautical Systems Division
ASTIA	Armed Services Technical Information Agency
AWS	Air Weather Service
BSD	Ballistic Systems Division
CRPL	Central Radio Propagation Laboratories
DASA	Defense Atomic Support Agency
ESD	Electronic Systems Division
IR	Infrared Radiation
NASA	National Aeronautics and Space Agency
NBS	National Bureau of Standards
NRL	Naval Research Laboratories
R&D	Research and Development
SPO	System Program Office
SSD	Space Systems Division
TRAP	Terminal Radiation Airborne Program
USWB	United States Weather Bureau
WS	Weapon System

SECTION 1

Introduction

Purpose. This report describes the what and the why of present and future Air Force Systems Command requirements for natural aerospace environmental data and information. It enumerates the environmental parameters about which information is desired and discusses the purposes for which the information is or will be used. The survey was undertaken at the request of Headquarters USAF. Included here are substantiated, qualitative statements of need for data or support, without regard to whether the support requires R&D action or can be met through existing state-of-the-art technological capabilities. Development of equipments and techniques will certainly be required to fill the gaps in our knowledge and capabilities, but these requirements are not discussed. This report provides background information for those who plan and estimate resources for future natural environmental support to the USAF.

Definition. As used here, environmental information includes observations, statistical descriptions, studies or predictions of natural environmental parameters or phenomena. Examples of parameters or phenomena are atmospheric winds, density, composition, electron density, proton showers, auroras, meteoroid environment, cosmic rays, and spatial force fields.

Need for Environmental Information. The capability of a system to perform a specific task is usually affected to some degree by the natural aerospace environment. Consequently, environmental effects must be identified and their impact on a system evaluated. Some effects prove to be insignificant, others may be "designed out" of a system, and still others may be observed or predicted so as to enhance system effectiveness. Space age systems must be designed and developed to operate in new and often hostile environments. A major problem, however, is the fact that although the characteristic of these new environments are unknown to a large extent, economical design and testing of the system require specific knowledge of the environmental parameters. The desired level of knowledge is a complete description of each parameter including variations in time and space and interrelationships between parameters. This ideal state of affairs can be approached but never reached. Thus, trade offs are necessary. In the development phase of system acquisition, the lack of adequate environmental information can result in resource and time losses; systems must be over-designed; required number of tests is increased; and time is lost bringing a system to an operational status. When significant environmental effects are discovered after a system becomes operational, the necessary modification can

be costly in time, money and degraded national security. The national requirement for knowledge of the space environment is clear. Military systems must be developed in the light of detailed knowledge of the natural environment.

Limitations of Existing Data and Dissemination Procedures. Some data on each of the parameters or phenomena discussed here are available. In most cases, however, something more is desired because of incompleteness, inaccuracies or other deficiencies. Where deficiencies exist, tests can usually be devised to provide environments which are more hostile than those reasonably expected and a device can be built to withstand these environments (Reference 2).

However, this approach results in over-design and necessitates more tests than would be required if adequate knowledge of the environment were available.

Until recently, the collection and investigation of data in the space environment above the altitudes of balloon borne instruments was accomplished by indirect probing techniques and was primarily a matter of scientific interest. Operations in space require that we expand our knowledge of the space environment. Research projects or experiments cannot gather sufficient data to meet Air Force needs, nor the needs of the scientific community in general. One realizes this fact when one considers that we have literally mountains of atmospheric wind data in the National Weather Records Center and yet we do not have wind and wind shear statistics in sufficient detail to meet the requirements of designers and engineers. For some environmental parameters discussed here, a long term, organized observational program is needed to obtain sufficient compatible data to describe statistically or to predict environmental conditions. When such observation programs are undertaken, steps must be taken to insure that the data are preserved. USAF can accomplish this by designating specific agencies as offices of record, responsible for receiving, storing, and disseminating all such data obtained.

The National Records Center is the national archive for meteorological data, generally below 100,000 feet. The USAF through its Air Weather Service Climatic Center provides an integral part of the National Weather Records Center. The Climatic Center provides data, statistical descriptions and studies to military agencies and contractors.

Efforts are being made in the military services to collect and store environmental data from levels above 100,000 feet. For example, the U.S. Army, in cooperation with the Meteorological Rocket Network of the Inter Range Instrumentation Group, reduces, analyzes and evaluates data obtained from rocketsondes to altitudes of about 250,000 feet.

These data are eventually stored in reduced form at the National Weather Records Center. However, military agencies and contractors are requesting environmental information which cannot be supplied satisfactorily using presently available data.

AFSC Survey. To gain insight to this requirements problem, AFSC requested each of its systems divisions and test centers to comment on its present and future needs for natural environmental information. Comments were requested in the following format:

1. Environmental parameter.

2. If data on this parameter are currently being used, describe the kind of data, e.g., observations, predictions, statistical.

3. Are the data being used adequate/inadequate?

4. What systems require the data?

5. Describe the manner in which the data are used for each system. Differentiate between design need and operational need; indicate degree to which data enhance system success.

6. What agency provides these data?

7. If the provider is not an AF agency, discuss the desirability of establishing an organic USAF capability to collect or provide these data.

8. Will future USAF data requirements increase or decrease?

Format of this Report. In the sections that follow, parameters are divided into groups and discussed individually or, where permissible, collectively. The parameter groups are:

Group I: Those atmospheric parameters that have long been of concern in classical meteorology and are now of interest to great distances from the earth's surface.

Group II. Space parameters characteristic of the interplanetary medium, for example, radiation and meteorites.

Group III. Atmospheric parameters, important in near-earth phenomena, which have recently become of concern for diverse reasons. Examples are micrometeorological diffusion parameters, acoustical propagation properties, infrared radiation characteristics, optical and electromagnetic index of refraction, and electrical properties.

Discussions of the parameters follow a sequence: the parameters are described; our current state of knowledge is discussed; and current and future requirements for information on the parameters are summarized. Following each summary are specific requirements expressed by AFSC divisions and centers in response to the survey.

SECTION 2

Group I Parameters

Thermodynamic Parameters and Winds. The gross features of atmospheric density* and wind distributions are fairly well-known to altitudes reached by balloon-borne sounding instruments (100,000 feet). Density data above 180-200 km has been and is being obtained from calculations of the drag-induced orbital decay of satellites as well as from satellite borne instruments. There remains, however, a gap in our knowledge of density and wind in the 30 to 85 km layer and a more serious gap in the 85 to 180 km layer.

At the present time only preliminary determinations of seasonal and latitudinal mean values of wind and density in the 30-60 km layer have been made; these are based on sparse rocketsonde observations for which the accuracies of instrumentation or observing techniques cannot be stated clearly. Above 60 km to about 180 km, information is even more sparse and less reliable since it is based on interpolations of data obtained above and below the level of interest. The data required are statistical descriptions of density and winds, including variability in time and space. A 12 hour prediction capability is also required (Reference 3).

Some high level synoptic data are now being acquired through the efforts of the Meteorological Rocket Network, an informal group organized under the Inter Range Instrumentation Group of the National and Service Ranges. Although the initiation of the Meteorological Rocket Network has resulted in increased data and knowledge, it is only a first step in meeting Air Force requirements. More recently (November 1962), a pilot operational meteorological rocketsonde network was initiated by USAF. All U.S. groups who fire rocketsondes are cooperating in this data acquisition effort. A most important factor in obtaining these high level atmospheric data is the simultaneity of the observations. Simultaneous (synoptic) observations provide instantaneous spatial descriptions of the parameters involved.

Information on atmospheric thermodynamic parameters and winds are required in all phases of the life history of military systems. An early use is for the development of structural design criteria for military systems. Individual samples of data are used to determine the cause and magnitude of expected flight loads; predictions of future vehicle load experience is based on statistical environmental data.

* Statements apply to temperature and pressure as well as to density.

Wind and density information required to support tests takes many forms. Statistical data are used in planning flight tests. Forecasts are required in making launch decisions. Observed data are required in reducing test data. It is in the evaluation of test data that accuracy requirements are most stringent. For example, the aerodynamic characteristics of a lifting space vehicle are functions of ambient density, among other variables. An error analysis reveals that in order to establish aerodynamic characteristics (i.e., lift coefficients, drag coefficients, etc.) with a root-mean-square-error (RMSE) of 5%, ambient density must be measured with an RMSE of 4%.

Density information is required in the construction of ephemerides for orbiting vehicles. Accurate position forecasts are essential to the success of missions involving satellite mapping, reconnaissance, communications or rendezvous.

Although the need for density and wind information in the re-entry and low orbit zones has long been acute for design purposes, the operational requirements for these data will become more stringent as Air Force activities in these zones increase.

Specific Requirements: Thermodynamic Parameters and Winds.

Source: ASD (DASP), Directorate of Advanced Systems Planning.

1. Parameters: High-altitude temperature, pressure, density and variations of these above 100,000 feet.

2. ARDC 1959 Standard Atmosphere (statistical) is used. Observations are desired.

3. Data used are inadequate, in that we have no way of actually knowing the state of the atmosphere at these altitudes during vehicle launch or re-entry. The ARDC model represents a mean profile at mid-latitudes and does not represent temporal or latitudinal variations which may be quite significant.

4. Ballistic missile and re-entry vehicle systems require this data.

5. These data are needed in the design, analysis, and evaluation of conceptual systems. Among other things, the data are used to calculate vehicle drag, aerodynamic characteristics, re-entry heating, etc.

6. Air Force Cambridge Research Laboratory supplies currently used information.

7. An active program to measure and collect these high altitude data on a synoptic scale is needed.

8. Requirements will increase.

Source: ASD (ASRMDS-3), Structural Loads Section.

1. Parameters: Wind, temperature, pressure, density and humidity. The following environmental parameters are required coincident with aerospace vehicle launch, climb, cruise and descent. Consequently these parameters will be measured from sea level up to the maximum height of each aerospace vehicle. Obviously some of these parameters are nonexistent at high altitudes (ionosphere and above) and in these instances such requirements are deleted.

a. Wind velocity and direction (sea level to 400,000 feet).

b. Gust velocity and direction (sea level to 400,000 feet).

c. Temperature (sea level to 400,000 feet).

d. Pressure (sea level to 400,000 feet).

e. Density (sea level to 400,000 feet).

f. Humidity (sea level to 400,000 feet).

2. Usable data consists of measured observations and statistical data.

3. Not all of these parameters are being recorded and in some instances none of them are available. Environmental data are generally inadequate.

4. These data are not required for any particular existing system analysis as such, but for the development of structural design criteria for future USAF flight systems.

5. Environmental data are used to determine the cause and magnitude of the measured structural flight loads data and to predict future vehicle load experience based on statistical environmental data. These analyses are performed to provide a basis for developing design criteria for different weights and configurations. This total effort is designed to insure the development of structurally feasible military vehicles.

6. Data have been provided by Air Weather Service.

7. Not applicable.

8. Future USAF data requirements will increase because of extended missions into space and other planetary atmospheres.

Source: AFFTC, Directorate of Flight Test.

1. Parameters: Upper altitude (i.e., 100,000 to 700,000 feet) atmospheric density, temperature, pressure, wind direction, wind speed. Upper altitude (i.e., greater than 300,000 feet) atmospheric composition.

2. There are specific measurements of temperature, wind direction, and wind speed made in the range of zero to slightly in excess of 200,000 feet in support of the X-15 program. Statistical data are presently being used in planning for flight test of the Dyna-Soar.

3. The environmental data presently being obtained in support of the X-15 program are useful in determining true speed and Mach number. The lack of upper altitude data, such as density, has limited the success of the X-15 program in that it has not been possible to obtain high altitude aerodynamic parameters. There is no alternative to the use of statistical data in flight planning for Dyna-Soar. Statistical data are, therefore, always useful; however, the degree of uncertainty as well as the degree of parametric variation requires that analyses be performed to determine the effect of such variations.

4. X-15 and Dyna-Soar require these data.

5. In the X-15 program, high altitude atmospheric data are required for data reduction purposes. Lack of this data is not critical to the success of test flights, but may be for future tests. In the Dyna-Soar program, data are required for flight test planning and for data reduction. The quality of the data obtained from the flight test program is directly dependent upon the quality of upper atmosphereic data. For example, an uncertainty in density of ± 20 percent results in a ± 20 percent uncertainty in such parameters as the lift coefficient and drag coefficient, etc. The desired measurement accuracy for upper atmospheric parameters is as follows:

PARAMETER	MAXIMUM RMS ERROR
Density	5 percent
Pressure	5 percent
Temperature	4 percent
Wind speed	20 knots or 20 percent, whichever is greater
Wind direction	± 20 degrees
Wind shear	20 percent or .02 ft per sec, whichever is greater

6. Atmospheric measurements in support of the X-15 program are being made at Pt. Mugu NAS, California. Many agencies supply the statistical atmospheric data being used in the Dyna-Soar program.

7. Not applicable.

8. Future USAF requirements for upper atmospheric data undoubtedly will increase.

Source: APGC (PGOPL), Plans and Operations.

1. Parameter: High atlitude density.

2. Currently observations are made to about 250,000 feet.

3. Data presently collected are adequate for present requirements.

4. Systems which are expected to utilize these data are boost glide vehicles and re-entry vehicles.

5. Data will be used in the design of future space probes and in the operation of these vehicles on the edge of space.

6. Agency to provide this would be Detachment 10, 4th Weather Group, Air Weather Service.

7. Not applicable.

8. The requirements are presently nil but will become great.

Source: Program Director, Dyna-Soar System Program Office.

1. Parameters: Pressure, density and winds. There are basically two types of meteorological measurements required for the Dyna-Soar Flight Test Program. The first involves a forecast of the expected conditions along the flight path at the time of launch approximately twelve hours before launch time. This is needed to determine whether to proceed with the launch considering the effects of atmospheric conditions on test objectives and vehicle structure limits. The second involves the measurement of atmospheric properties at the time of flight for the purpose of research data reduction.

2. In the launch area, the following measurements will satisfy both the advanced forecast and research data reduction requirements for the flight test program. Data are required from sea level to 100,000 feet for forecast purposes and from sea level to 350,000 feet for research data reduction.

Measurement Item	Accuracy
Density	$\pm$ 5%
Pressure	Current capability
Temperature	$\pm$ 5.0°F
Wind velocity	$\pm$ 15 ft/sec
Wind direction	$\pm$ 5°
Wind shear	$\pm$ .01 per sec or current capability

These measurements should be made at 1000 foot intervals from sea level to 60,000 feet and at 5,000 foot intervals above 60,000 feet.

3. Density and density gradient information are the primary meteorological data required along the re-entry flight approximately twelve hours before launch decision. Sufficient measurements are required to forecast the probability of encountering horizontal density gradients greater than 30 percent per 50 nautical miles and density departures greater than 50 percent from the ARDC 1959 atmosphere. Sharp edged horizontal gradients, if they occur, are most important because of the momentary increase in surface temperature before the glider responds to the gradient. High altitude winds, velocity and direction, are not of direct concern unless they produce density gradients of the order stated above. The altitude range that should be covered is from 150,000 feet to 300,000 feet.

4. The atmospheric data in the re-entry corridor required for research data reduction are as follows:

Measurement Item	Accuracy
Density	± 5%
Pressure	Current capability
Temperature	± 5°F

The altitude range is the same as noted in paragraph 3 and measurements should be obtained as close as possible to the time of flight.

5. The location and number of measurements made along the re-entry path depends upon the ability to estimate the density and density gradients between the measurement stations and cannot be specified at this time. Since the accuracy of the flight research data is a direct function of the meteorological data accuracy, sufficient measurements should be planned to avoid large errors in estimating atmospheric properties between stations. The number and locations of the stations and acceptable error dispersions between stations will be established by the Dyna-Soar SPO after consultation and coordination with the responsible agency for meteorological data for the Dyna-Soar Flight Test Program.

6. Two wind profiles from sea level to 100,000 feet will be of primary concern for structural design purposes. Winds above this altitude are not expected to produce critical design conditions for the Dyna-Soar vehicle.

7. In addition to the above high altitude data, meteorological measurements are needed from sea level to 100,000 feet at the landing site, Edwards AFB. General surface weather conditions such as cloud cover, visibility, winds, and sea state are also needed along the flight path and will be obtained through the use of existing capabilities.

NOTE that the information provided is not in the prescribed survey format.

Atmospheric Composition: By the term "atmospheric composition" is meant the chemical constituents of the atmosphere from the earth's surface to altitudes in excess of about 2000 km. Atmospheric composition is fairly well-known in the tropospheric levels. The actual composition of the stratosphere is believed to vary but slightly from that of the troposphere, but these minor variations are important for two reasons. First, changes in the concentration of the chemically inert constituents are probably indicative of diffusive separation which indicates that the proportion of lighter gases will increase with height. Second, the thermal state of the atmosphere is dependent upon the concentration of three minor gases; water vapor, ozone and carbon dioxide (Reference 4). It should be noted that these three gases are of critical importance to some reconnaissance systems. It would be erroneous to assume that the ionosphere resembles the lower levels in chemical composition. Photochemical theory indicates that there should be a strong increase in the relative percentage of atomic oxygen above 90 km. Other indications are that water vapor probably decomposes above 70 km and carbon dioxide above 100 km and that diffusive agencies become dominant somewhere above 100 km with attendant rapid increase in the proportion of lighter elements with height. Finally, auroral and nightglow spectra indicate that oxygen, nitrogen, hydrogen and sodium atoms as well as ions and free radicals are present at the higher levels (Reference 5). The concentrations are believed to be small, but for application to some systems they need not be large to be important. Most of what has been stated is highly speculative, the major limitation to knowledge being that of the limited scope and coverage of data. As in other fields, observations in three dimensions as well as statistically derived variations in time and space are needed. The scope of such an observational program is tremendous, but effort should be made to attain at least a working knowledge of the near-earth environmental atmosphere.

The composition of the atmosphere is important for several reasons. The detection of vehicle trails and plumes requires a rather detailed knowledge of the photochemical and collision reactions that occur when exhaust gases foreign to the environmental atmosphere are released. To attain that knowledge, a knowledge of the atmospheric composition is essential.

Knowledge of the composition is needed to evaluate the potential of a high altitude nuclear burst for producing widespread interruption of communications. This phenomenon has been termed blackout because of its similarity in effect to auroral blackout. The ionization produced depends on the atmospheric composition as well as the burst characteristics. By proper selection of burst size, height and location, any communications system depending on reflection from the D, E, or F regions can be severely affected for several hours. To assess this capability, detailed knowledge of the chemical makeup of the atmosphere is required.

Other requirements stem from a need to know the atmospheric constituents for possible utilization as energy sources as well as for investigation and relation to radiation effects on meteorological phenomena in the troposphere.

In the regions of 50 to 90 km, the Air Force and NASA are the only agencies known to be making direct observations. Above 90 km, both the Air Force and NASA are making observations with sounding rockets and satellites. NASA has its Atmospheric Structure Satellite for these purposes, whereas the Air Force relies principally on "piggy-back" experiments. Due to the large number of observations required to attain a working level of knowledge, it is estimated that it will take at least three years of concentrated effort by both of these agencies to acquire sufficient data for analysis. A single agency should be designated to collect and store the data that are obtained during this period and to reduce it to a standard format for ease of analysis. Air Force interest in this problem will continue until such time as the atmospheric composition and its time-space fluctuations are sufficiently well-known for Air Force operations.

Specific Requirements: Atmospheric Composition.

Source: ESD (Plans and Programs).

1. Parameters: Upper atmosphere density and composition.

2. For the most part observations are currently used, but some use of predictions is made.

3. Observations are made at the present time on a research basis only. This research, however, will determine the frequency and spatial scale required for operational use.

4. The 496L (SPADATS) system requires these data.

5. Data are used operationally in 496L for prediction of orbits. At present time for low perigee orbits (200 nm or less) the data can be used in predictions to within a five degree solid angle for periods up to a maximum of a week. The shorter the prediction period, the more the observations that are required per vehicle, increasing the data handling problem.

6. The Air Force and the Meteorological Rocket Network provide the data. The AWS provides data at the missile test ranges.

7. It would be desirable to have increased AWS participation in operational observation and prediction.

8. Requirements for these data will increase.

Source: BSD (BSRVT-3), Ballistic Missile Re-entry Systems Office.

1. Parameter: Atmospheric Ozone at Flight Altitudes.

2. These data are not now being used.

3. The lack of ozone measurements has not been considered serious in that they are of value principally in combination with humidity data, which have not been available either.

4. Data on ozone will be of use in assessing the atmospheric transmission for the TRAP radiation measurements.

5. Data on ozone content at flight altitude can be correlated with water vapor content above the aircraft, thus enhancing the radiation attenuation measurements of the TRAP program.

6. Ozone content measurements at flight altitude are not presently obtained.

7. Because of the simplicity with which ozone measurements can be made aboard an aircraft and of the value to the TRAP program, other military projects and geophysical investigations it seems highly desirable that such measurements be made on selected Air Force aircraft operations.

8. Unknown.

Cloud Cover and Background Radiation Observations. The requirement for cloud cover observations is related to the requirement for background radiation data in that cloud cover is one of the main factors in the reduction of the capability of satellite detection systems to perform their missions. Additionally, cloud cover data, meaning current observations, are required to predict future cloud conditions over areas of interest to Air Force operations. Of particular interest are: forecasts of cloud conditions over specific target areas to be used in making "go-no go" decisions for certain operations; forecasts for aerial recovery operations; and forecasts to be used in identifying spurious infrared returns from cloud tops during satellite reconnaissance or detection missions.

Actual observations are also needed for correlation with observed infrared returns. Statistical information built up from actual observations is needed to provide design criteria and to determine feasibility of proposed systems.

At the present time cloud observations are made routinely at surface weather stations throughout the world. These data, however, are quite inadequate for purposes of space missions since even the relatively close network of observing stations within the United States does not provide sufficient information to describe cloud formations completely. This has been illustrated by the TIROS series satellites. The TIROS experiments provide the best information on cloud coverage yet available but it is estimated that this system will not be fully operational until 1966. The TIROS data do not adequately meet Air Force needs since geographical areas of interest are not under continuous surveillance. Also the concurrent infrared radiation data taken in conjunction with the cloud coverage data is not usually available until some months later. The delay is due to data reduction and interpretation difficulties, but this does not lessen the impact on Air Force needs.

The Air Force should acquire a capability to meet its own requirements for cloud cover data during the period that the NASA programs are inadequate for Air Force operational needs. When the NIMBUS or later system fully meets Air Force requirements, the Air Force program would be discontinued or included in the national program. Collection and interpretation of cloud data during this period should be an Air Force responsibility, but past experience of the NASA programs should be fully utilized. The Climatic Center, Air Weather Service, is the natural agency to store and disseminate all such data obtained. The need for world-wide cloud cover data will undoubtedly increase, not only for application to space missions, but also as a basic input to routine weather forecast programs.

Specific Requirements: Cloud Cover and Background Radiation.

Source: SSD (SSZM), WS 239A Directorate.

1. Parameter: Infrared properties of reflected sunlight.

2. Observations, predictions and statistical data are presently used.

3. More complete and meaningful data are required.

4. WS 239A requires these data.

5. Information on IR properties of reflected sunlight is required to allow optimization of signal to background intensity ratios in design, R&D tests, and, eventually, an operational system. This is an extremely critical parameter, since signals must be readily distinguishable over background in order to have a workable system.

6. Most data are obtained from Air Force-contractor projects; some are obtained from civilian agencies.

7. It would be highly desirable to establish an organic USAF capability to consolidate the requirements, design the experiment, collect the data and provide cross-correlated, qualified, standardized data for all requesting agencies.

8. USAF data requirements will increase in the foreseeable future. Sufficient measurements must be obtained to firmly establish values for certain parameters. When this is accomplished, the requirements for that particular type of data will drop to a "monitoring only" level. However, new requirements will more than replace those for which established values can be given.

Source: SSD (SSZDP), 622A Program Directorate.

1. Parameter: Earth's thermal radiation balance.

2. Observational and theoretical data are presently being used.

3, 4, & 5. Data is used to compute expected satellite temperatures. Knowledge of the earth's radiation is one of the important factors, but passive temperature control is more of a black art than a science and our knowledge of the earth's radiation is probably more precise than our knowledge of other factors which affect the satellite heat balance for program 622A vehicles.

6. AFCRL provides the data.

7. Not applicable.

8. A constant level, continuing effort to refine our knowledge of this parameter will be appropriate.

Source: ASD (ASRMFP-1), Dynamic Energy Conversion Section.

1. Parameter: Thermal radiation balance (as pertains to re-radiation).

2. Predicted and some probe and orbital data are used.

3. The predicted values of thermal re-radiation from the earth depend highly on such things as cloud cover and orbit. Therefore, the worst conditions can be assumed so that a reliable system can be designed.

4. These data are used in designing radiators for space power systems orbiting the earth.

5. These data are used in determining the sink temperatures to which a radiator is rejecting heat. It is important in designing the radiator, and it is also important in the actual operation of the radiator. However, for a high temperature radiator this factor is not critical to system operation as it could be for a low temperature radiator.

6. These data are generally collected by AFCRL and by NASA.

7. Not applicable.

8. Future USAF data requirements in this area will probably increase.

Source: BSD (BSRVT-3), Ballistic Missile Re-entry Systems Office.

1. Parameter: Backscattered solar radiation.

2. No data of this type are currently in use in the TRAP project. Other projects requiring such information rely on theoretical calculations mainly. The TIROS radiation measurements provide low resolution data for orbital paths.

3. The flux of backscattered radiation is supplemental for the TRAP program, but for many other systems (program 239A, for example), it is of prime importance. For project TRAP it can be used to derive information on the general atmospheric turbidity and thereby provide estimates of the prevailing radiative transmission coefficients.

4. Systems which use radiation in the spectral range 0.2 to 4 microns for detection, discrimination or control are critically dependent on this information.

5. Sunlight is returned to space by both scattering and reflection processes -- scattering by air molecules or particulate matter in the atmosphere and reflection from the ground or water surfaces. At shorter wave lengths molecular scattering is the predominant process by which sunlight is returned to space, whereas at longer wave lengths large particle scattering becomes more important. The theory of Rayleigh scattering provides reasonably good integrated flux values for a very clear atmosphere. However, the atmosphere always has sufficient turbidity to enhance the upward flux considerably. By a comparison of measured values with those computed for only Rayleigh scattering a good estimate of the atmospheric particulate content can be made.

6. There is no agency, so far as is known, that supplies these data at aircraft altitude.

7. There are two reasons why it would be desirable for the Air Force to make these measurements. First, the data could be used to obtain good estimates of atmospheric transmission coefficients. Second, these data are of basic importance in the study of many atmospheric radiative transfer problems, such as the determination of planetary albedo and atmospheric energy budgets, the horizontal or slant visibility in the atmosphere and the radiative background against which objects must be seen from satellite altitudes.

8. Unknown.

Source: BSD (BSRVT-3), Ballistic Missile Re-entry Systems Office.

1. Parameter: Intensity of sky-background radiation.

2. Data presently in use consist almost entirely of theoretical calculations.

3. Observations are required. Theoretical calculations are only as good as the models on which they are based and actual conditions often do not correspond well to the idealized conditions assumed.

4. The TRAP program requires the data.

5. Measurements of radiation emitted by re-entry vehicles must be corrected for sky-background radiation in the near infrared, visible and ultraviolet wave lengths. The intensity of the scattered sunlight largely determines the feasibility of making daylight re-entry measurements.

6. Data on intensity of rocket background radiation are normally not available.

7. It is considered highly desirable that these data be collected for the TRAP project.

8. Unknown.

Ionospheric Data. A most important effect of solar ultraviolet radiation on the upper atmosphere is the ionization of its constituent gases at heights from about 60 km to its upper limits. The degree of ionization is not uniform with height or time. It is affected by many phenomena, such as solar flare activity and induced electric currents, as well as by the composition of the upper atmosphere itself (Reference 5). The ionosphere plays an important role in the propagation of radio waves and is of considerable, but as yet, not fully understood importance on its effect on phenomena in the lower atmosphere. Many aspects of the ionosphere are of importance to space missions. Among these areas are electromagnetic communications, detection and surveillance of missiles and satellites and the electrical effects on the orbital dynamics of satellites. Although the ionosphere has the property of reflecting radio waves sent upwards from the earth's surface, it acts as an attenuating medium of electromagnetic waves traveling within it due to the absorption of electromagnetic energy by the ionospheric electrons. This absorption is a function of electron density. Data on electron density has been obtained for many years by means of radio wave sounding techniques. It was once thought that there were distinct layers of electrons in different regions. In recent years with the advent of rocket measurements it has been determined that these "layers" are not distinct maximum electron concentrations but are more often only areas of low gradients of electron density (Reference 6). The use of direct observations has increased the knowledge of ionospheric effects, but more data are needed, particularly data on electron density and temperature as functions of altitude, latitude and time. The intensity of ionospheric variations should be related to solar activity but sufficient data are not yet available for reliable correlation. Ionospheric data are an obvious requirement for communications systems. For detection systems the composition of the ionosphere must be known. Other important factors are the ionization rate processes, collision frequencies of charged particles and the diffusion rates of foreign particles introduced by artifical means -- for example, missile exhaust plumes. The hydromagnetic characteristics may offer a reliable technique for the detection and identification of space vehicles, but sufficient data have not been acquired to evaluate this potential. Several agencies, including the Air Force, NASA and the National Bureau of Standards (Central Radio Propagation Laboratory), are engaged in making ionospheric observations. The Air Force and NASA use rocket probe and satellite instrumentation; the NBS uses radio wave sounding techniques primarily. Air Force interest in ionospheric data is high. Specific data and forecasting requirements will undoubtedly be delineated as space activities increase the need for uninterrupted space communications.

Specific Requirements: Ionospheric Data.

Source: ASD (DASP), Directorate of Advanced System Planning.

1. Parameters: Aurora, ionosphere variations, electron densities, sporadic E. etc., as related to radio wave propagation.

2. Data being used include observations, statistical analyses, and predictions.

3. Available data are considered adequate for advanced system planning purposes. However, the predictions of future conditions are not sufficiently accurate for good operational planning of operational frequencies, outage periods, etc., for long-range communications in the MF-HF frequency region.

4. Any systems making use of radio wave propagation, particularly in the MF-HF region of the spectrum, require such data.

5. Data are used in determining communication system parameters and design, and in operational planning. In some cases, operational success of a communication link may be almost wholly dependent upon accurate predictions. However, various means (amounting to experimental determination of a suitable frequency at time of communication) have been developed over the years to offset this dependence.

6. Data are available in various Government and commercial handbooks, including monthly "Basic Radio Propagation Conditions" issued by the Central Radio Propagation Laboratories. CRPL apparently is the principal source of such data.

7. We see no need for USAF to duplicate the service provided by CRPL.

8. As USAF turns more and more to other means of accomplishing long-range communication, the data requirements in this area will decrease.

Source: SSD (SSTRE), Spacecraft Technology Division.

1. Parameters: Plasma and ION sheath. The various aspects of these phenomena that require extensive investigation include:

   a. Plasma frequency as a function of altitude.

   b. Ionization rates within the plasma as a function of temperature.

   c. Electron density.

   d. Magneto hydrodynamic effects on the plasma.

   e. Dielectric properties of the plasma.

   f. Chemical disassociation and recombination rates.

2. Data presently used are statistical and predictions based on past flights.

3. Data used are inadequate since there is a clear and present need to supplement the present analytical results with test data.

4. The data are used and needed by all communications systems for super-orbital re-entry vehicles.

5. To achieve an operational, continuous two-way communication system, these parameters will have to be more accurately known. The selection of the proper transmission frequency will be the major operational parameter that will determine the design of adequate power sources.

6. The data are furnished by governmental, educational and corporate institutes.

7. It is recommended that a USAF capability be established to collect, correlate, monitor and evaluate the present non-integrated efforts throughout the aerospace industry.

8. Requirements for these data will increase.

Source: ESD (Plans and Programs).

1. Parameter: Aurora (perhaps also airglow).

2. Observations and predictions are currently used.

3. Adequacy of the data is only fair.

4. Systems that require the data are 465L (SAC Control System), 466L (ELMINT), 473L (AFC&C), 474L (BMEWS).

5. Statistical data is used in design, in the selection of frequencies to be used. It is used in operations to avoid background noise. Predictions of simultaneous occurrence of aurora at all BMEWS sites with an attendant evaluation of the effect on warning systems under this condition is required.

6. University of Alaska, AFCRL, NBS (CRPL) currently provide data.

7. It is desirable that operational observations for specific purposes (such as for 465L and 474L) be made.

8. Future requirements are unknown. They will depend upon frequencies used in sensors and communications of the future.

Source: ESD (Plans and Programs).

1. Parameter: Electron density with altitude.

2. Observations and predictions, most likely based on statistics are currently used.

3. CRPL monthly predictions are fair, but more definitive forecasts are needed. International network of ionosonde stations (formed in IGY) provide good observational data.

4. Systems that require these data are 465L (SAC Control), 466L (ELMINT), 496L (SPADATS).

5. Electron densities in the ionosphere regions cause refraction and absorption of EM frequencies up to and including VHF. The ionospheric electron densities are subject to sudden anomolies. Forecasts of disturbances enter into status determination of communications and planning of message flow rates.

6. NBS (CRPL) currently provides the data.

7. It would be desirable for the AWS to have a joint capability and responsibility with CRPL for prediction and dissemination of electron density data.

8. Requirements for these data will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameters: Ionosphere variations and electron density.

2. Data used are based on observations and on prediction theories.

3. Average values and the variations in the data available are inadequate.

4. Systems involved: 64-D, 65-A, 65-B, 65-C, 65-E, 65-F, 66-B, 66-C, 66-D, 76-A, 67-B, 70-A.

5. Data needed for design of vehicles.

6. USAF: Geophysical Institute, Boulder, Colorado; Service Du Rayonnement IRM UCCLE, Belgium; Jodrell Bank Experimental Station, England; NASA and others supply current data.

7. USAF should collect and correlate more data.

8. Future requirements for data will increase with respect to accuracy and distribution within the upper atmosphere.

SECTION 3

Group II Parameters

Radiation. Many types of space radiation with different characteristics must be considered here. From the standpoint of weapon system reliability, however, the various types of radiation can be discussed under two major headings according to the effect on specific systems. These are:

a. Natural background radiation, important to reconnaissance and detection systems.

b. Particle radiation, important to the proper functioning of electronic components and to the health of crew members.

Natural Background Radiation. This discussion includes those phenomena that affect the radiation background as viewed from a vehicle in space (a detector can be designed to "view" in many different regions of the electromagnetic spectrum). Among these phenomena are:

a. Space radiation -- i.e., solar, stellar, and other radiation from space.

b. Aurora -- radiation caused by excitation of atmospheric molecules or particles by impingement of high velocity particles coming from space along the earth's magnetic axis.

c. Airglow -- radiation caused by photodissociation and recombination.

d. Zodiacal light -- radiation or reflection from particulate matter presumed trapped in the high atmosphere along the ecliptic.

e. Lightning -- radiation in many spectral regions that occur with lightning discharges.

f. Albedo -- the ratio of reflected to incident radiation, but which differs with type of reflecting surface, i.e., clouds, water surface, snow caps, etc.

Although a great deal of data has been collected on most of these phenomena, the observations, in general, were not designed to determine the overall background radiation as viewed from a satellite.

Rather, previous analyses were made to determine spectral identification or sources of the radiation in specific spectral regions. Most of the data were obtained from airborne or ground based observations which suffer from the attenuation of radiation by the earth's atmosphere. Specifically, a satellite "looks" down upon the earth in the opposite direction from which the ground based observing instrument "looks." The absorptive and reflective characteristics of the atmosphere completely change the character of the incoming radiation from that which is re-radiated to space. Even so, only limited information of this nature is available since the data were obtained at isolated points and not on a world-wide or continuous basis.

At the present time a number of Air Force, NASA and ARPA projects are in progress to gather more pertinent information. These programs are generally limited to the infrared or near infrared spectral regions and to the rotational/vibrational spectrum of only two gases, namely water vapor and carbon dioxide. These two gases strongly attenuate radiation in the spectral regions mentioned. It is of interest to the Air Force to investigate the use of other spectral regions in the area of reconnaissance and detection and some effort has been given to the possible use of ultraviolet sensing. However, the major spectral region of interest lies between 0.5 and 15 microns. Other regions of lesser interest should, nevertheless, be mapped. A knowledge of and interpretation of background optical radiation has a very real impact upon the success of reconnaissance, surveillance and detection systems. These systems are required to operate against a radiational background which is known to vary extensively in intensity and spectral content and in time and space. These variations constitute a fundamental difficulty, in that the system must resolve even minute point fluctuations and distinguish them from targets of interest. The targets of interest can be classified according to their own and reflected radiation and fall in four general classes, rockets, satellites, airborne and ground based objects, all of which have different absorption/emission characteristics. Detection and early warning systems rely on a capability to detect and distinguish radiation from a missile exhaust plume. Detection and recognition of satellite vehicles is based on the thermal and reflected solar radiation from the vehicle itself. Identification of ground based targets is based on reflected solar radiation to a large extent.

Current Air Force projects include experiments to determine target and background radiation in the infrared and ultraviolet regions. A large amount of data concerning earth radiation in the infrared is available from the TIROS satellites. These data are of necessity, specialized in that they were obtained to answer specific questions. Its interpretation is difficult to say the least. However, it is not

generally available from a single source. It appears desirable to establish a single agency, to collect and store such data and provide it and studies based upon it as required. The Air Force would be a primary user. As development of more advanced reconnaissance and detection systems proceeds and as research into basic atmospheric processes advances, Air Force requirements for background radiation data will increase.

Particle Radiation. This discussion of particle radiation includes requirements for:

a. Data on the flux and energy spectrum of trapped particles.

b. Data on the flux and energy spectrum of solar flare particles.

c. Capability to predict solar flare activity.

All of these requirements are important to space operations in both manned and unmanned vehicles. The effects on these two types of systems differ and will be discussed separately.

The impact and penetration of a material by high energy charged particles affects all materials in a destructive or mutational manner. The degree of the destruction, of course, varies with the material and the energy of the impinging particle. Most metals for example can withstand exposure to a far larger extent than most plastics. Miniaturization, as well as electronics reliability, has required the use of plastic and semi-conductor materials in almost every electronic component in satellite vehicles. These include solar cells, IR detectors, thermal coating control and solid state components. Unfortunately, these devices must be located near the external surface of the vehicle for sensing purposes with little or no shielding permitted. Radiation damage to any of these components can seriously hinder or even negate the effective accomplishment of the vehicle's mission, even though all other components may be performing perfectly. It is possible, however, to decrease the destructiveness of radiation by careful design of the sensitive components. Among the factors that must be considered to do this is the type of radiation, its intensity and energy. This means that a detailed description of the radiation must be available to the designer to insure maximum component lifetime. It may also be possible to use lightweight shielding, but to do this a knowledge of the radiation must also be obtained. For manned systems, the problem is even more difficult. The degree of damage to man depends on the type of radiation, its intensity and energy, the duration of exposure as well as the particular body organs receiving the radiation.

Adequate shielding is the most obvious solution to the problem, but work has begun to find immunizing agents or drugs to increase the body's tolerance of radiation. However, to successfully counter radiation effects, the radiation that will be encountered must be known by type, energy spectra, location and variation. Many agencies both government and civilian, have been engaged in research on space radiation for several years. In spite of this, the amount of available data on trapped particles is extremely small. It appears that each experiment (particularly the Explorer series) produces new information which requires that previous theories or estimates be changed. This in itself is a clear indication that our understanding of the environment in the radiation belts is extremely limited. The Air Force and NASA are currently engaged in gathering more information to describe and explain the radiation from trapped particles. Most of these investigations are, however, only of secondary importance in the overall purpose of the experiment. The Air Force programs are mostly confined to piggy-back techniques and are not designed to provide all the necessary information.

Solar particles affect manned and unmanned space vehicles in much the same manner as do trapped particles. They may, however, prove to be the more dangerous phenomena to manned systems because they can be encountered anywhere in space, whereas the trapped particles are confined to near-earth regions. The duration of exposure to trapped particles may be reduced by proper selection of trajectories. Although solar flare radiation activity has been observed for a far longer period than that of the trapped particles, even less information is available concerning the energetic particles resulting from the flares. This is due to the fact that the atmospheric absorption limits the amount of data than can be obtained from surface observation. In addition, the earth's magnetic field deflects incoming particles in low latitudes. Such data as do exist indicate a great variability in flux and energy of the solar particles from flare to flare. The proton spectra from solar flares is very steep, varies from flare to flare and varies with time during a single flare in a manner not yet fully understood. In addition little is known of the history of the protons within a single flare. From past data it is known that solar flare activity varies in an eleven year cycle (approximate). During the last maximum (1957) solar flares occurred at the rate of thirteen per year; one or two flares occur during the minima of the cycle. During the next maxima (1968-69) the probability is 0.98 that at least one encounter of a major flare will occur if missions require 25 to 100 days of orbit or space travel during that period. If these missions are manned, the result could be disasterous. However, it may be possible to reduce the solar flare hazard, not by shielding, but by avoidance through prediction. Work has been started

in this field, but so far, although promising, the capability to predict the occurrence of major flares does not preclude the probability that space mission in the 1967-68 period will not encounter a major flare. At least a five-day prediction capability is needed. Without such a capability, the probability of man surviving prolonged intervals of time in space is low. A prediction capability would also be useful in prolonging the life and efficiency of reconnaissance and detection systems.

At the present time many agencies are engaged in observing and analyzing solar flare phenomena. Among them are Sacramento Peak Observatory of AFCRL, Lockheed Observatory, McMath-Hulbert Observatory, Kilt Peak National Observatory, Mount Wilson Observatory and NASA. Only the last of these mentioned is obtaining or plans to obtain data from space observations (Orbiting Solar Observatory).

Solar flares and attendant phenomena can adversely affect future Air Force operations. Consequently, the Air Force should closely examine the practicality of predicting such phenomena and consider developing an in-house observing, data handling and prediction capability.

Specific Requirements: Radiation.

Source: SSD (SSZDP), 622A Program Directorate.

1. Parameters: Solar flares and attendant phenomena (solar corpuscular radiation, X-rays, ultraviolet radiation).

2. Project 622A currently uses observational data. Predictions are not yet usable.

3. Data in the form of accurate, long range predictions are needed but are not available.

4. Data are required for Program 622A vehicles.

5. Data are required to evaluate effect on satellite sensors, electrical components, instruments as well as effects on the atmosphere.

6. Lockheed Missile and Space Company and AFCRL provide the data.

7. For future space operations the solar phenomena must be considered in exactly the same manner that weather data are presently used for terrestrial flights. An expansion of our present weather service is the only logical course of action.

8. Future USAF data requirements will increase dramatically.

Source: SSD (SSZN), Director, Program 698 AM.

1. General Parameters: Cosmic radiation, meteorites, cosmic dust and stellar radio emission.

2. Both predictions and observations are being used.

3. Some information is available for each parameter but data coverage in the space corridor around the equator is sparse. Moreover, much data reflect conditions in space at a given instant with few if any subsequent probes to estimate variable conditions. Present data are adequate only for crude design estimates. Data on solar flare timing are adequate for the present. However, predictions of solar radio noise are most vital when linked to stellar radio emission. These predictions should be centralized by one agency as launch dates and tracking sequences are dependent on good telemetry, i.e., low noise background.

4. Program 698AM is using data currently available.

5. Besides application mentioned in paragraph 3, these data will be used to assess mission performance under various natural environments. Dangers from meteorites are unknown. With the present level of knowledge, an assessment of Program 698AM spacecraft vulnerability to the natural environments is being made. Unfortunately, the sketchy data leaves much to be desired.

6. Agencies that provide data include but are not limited to NASA, NRL, NBS, USAF, Navy, Army, AEC and many educational institutions in this and other countries.

7. Perhaps the USAF could serve a very useful function to collect, process and provide solar behavior prediction and data.

8. No doubt, USAF requirements for data of the natural environments will increase as space missions demand travel even farther from the earth.

Source: SSD (SSZM), WS 239A Directorate.

1. Parameters: Radiation belts and electron density.

2. Primarily observations and statistical data are used.

3. More complete data are required for analysis and design purposes.

4. WS 239A requires these data.

5. Information on radiation belts and electron densities is required to design and incorporate shielding of the correct type critical components of the satellite as required or to eliminate weight from the satellite if shielding is not required.

6. Data are furnished from Air Force and other government and civilian agencies.

7. It would be highly desirable to establish an organic Air Force capability to collect and disseminate standardized data for all using agencies.

8. Requirements will increase in the foreseeable future.

Source: SSD (SSZN) Director, Program 698 AM.

1. Parameter: Outer radiation belt.

2. Observational data from past flights is the current data source.

3. Data to date are sketchy and at best provide only an inkling as to environmental constituents and boundaries.

4. Program 698 AM requires this type of data.

5. The data are used to define, in part, developmental flight limits, i.e., the apogee and perigee. In addition, such data assist in determining mission performance and the type and amount of background in the outer radiation belt.

6. To date, Explorer flights sponsored by NASA have provided these data.

7. Radiation belt data does not necessarily need to be collected or provided by the USAF.

8. Future Air Force requirements will increase if the Air Force plans to orbit a man/equipment in or near the outer belt for any extended period of time.

Source: SSD (SSZDP), 622A Program Directorate.

1. Parameter: Radiation belts.

2. Presently observational data are used.

3. Prediction capability would be most helpful.

4. Program 622A collects and requires these data.

5. Data are desired to evaluate effect on satellite sensors, instruments, and electrical components as well as effects on the atmosphere.

6. Lockheed Missile and Space Company and AFCRL provide data.

7. A central data collection, storage and dissemination agency is desirable.

8. Future Air Force requirements will increase.

Source: Air Force Missile Test Center (MTQFW).

1. Parameters: Radiation belts and electron density.

2. Data are presently not being used at the AMR.

3. Not applicable.

4. Satellite systems both manned and unmanned require such data.

5. Statistical distributions, observations and forecasts of regions of high radiation/electron density could profitably be used to select orbits that would reduce danger of electronic failure of satellite components. Furthermore, there is a need to know the energy spectrum of radiation as a function of time and space for bio-astronautical considerations.

6. Data are not provided directly to the AMR.

7. It would be highly desirable to have a single agency to provide data and information for use of requesting agencies.

8. The requirement will undoubtedly increase with expanding space activities of the Air Force.

Source: ASD (DASP), Directorate of Advanced Systems Planning.

1. Parameter: Radiation belts (Van Allen).

2. Data used includes observations, extrapolations of data points from observations, and statistical analyses.

3. It is suspected that present data are inadequate and that the early definitions of the radiation belts will be refined and changed as additional data points are obtained.

4. Satellite and space systems in general, require these data (Manned systems particularly).

5. Data are used in advanced system planning as one factor in orbit determination, exit and re-entry "corridors," etc., and for determination of shielding requirements for systems which penetrate the belts. Operationally, the radiation exposure limits imposed by the system design will of course have to be respected in operational planning. This can be a very critical item in system success; incorrect data can result in destruction or disabling of equipment and personnel by radiation.

6. Sources of information to date have been the technical journals, papers by Dr. Van Allen and others.

7. NASA and USAF are the obvious principal customers for such data. One or the other (but not both) should be responsible, and establish a central capability to collect and provide such data.

8. USAF data requirements will increase.

Source: ASD (DASP), Directorate of Advanced Systems Planning.

1. Parameter: Solar flare radiation.

2. Data used include observations, analyses and predictions.

3. Present data are grossly inadequate, particularly with regard to predicting the time and intensity of hazardous periods for space flight.

4. Any satellite or space system operating in polar or near-polar orbits, or at altitudes greater than a few hundred miles, requires the data (Manned system in particular).

5. Data are used in advance system planning as one factor in orbit determination, shielding requirements, and the need to provide "storm cellars" or mission abort capability for manned systems. Operationally, predictions of solar flare activity are used to determine "safe" periods for launch of manned space systems, mission abort and rescue requirements, etc. The data are crucially critical to safety of the human crew; somewhat less critical to equipment operation.

6. Sources of data to date have been the technical journals and separate technical reports by various investigators, including ASD and AFCRL personnel. Our significant source of data is the Sacramento Peak Observatory of AFCRL.

7. If it hasn't been done, it would be desirable to designate AFCRL as the central USAF capability to collect and provide such data. If so designated, it should serve NASA needs as well.

8. Future USAF data requirements will increase.

Source: ASD (ASRMFP-1), Dynamic Energy Conversion Section.

1. Parameter: Solar radiation pressure.

2. Unknown.

3. Data are accurate relative to design analysis.

4. Data are required for the design of solar energy collection systems.

5. Solar pressure produces additional torque on solar reflectors, particularly large size reflectors. This causes additional work relative to an orientation system, and consequently, requires additional orientation power.

6. Unknown.

7. Not applicable.

8. Future data requirements will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameters: Cosmic dust, solar winds, solar radiation pressure, and solar flares.

2. Present data result from observations, predictions, and general statistics.

3. Data are incomplete.

4. Subsystem concepts which require these data are basically the solar cavity-type and flat-plate solar thermoelectric generators and certain other solid-state conversion concepts such as pyroelectric and ferroelectric -- all require large areas.

5. Radiation, particle, etc., pressure has an effect on the aforementioned concepts due to the large areas required for the concepts' operations. More exact data than now available are required because future concept designs will be influenced by the area-pressure drag caused by the various pressure phenomena. No systems are now operational.

6. NASA and the Air Force both supply present data.

7. An Air Force capability to concentrate on collection of more data is desirable.

8. Future Air Force data requirements in this area will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameters: Radiation belts, X-rays, cosmic radiation.

2. Present data result from observations, predictions, and general statistics.

3. Data seem incomplete and somewhat inconsistent.

4. Subsystem concepts which require these data: flat-plate solar thermoelectric generator, high temperature thermoelectric generator, solar cavity-type thermoelectric generator, and miscellaneous other solid-state conversion concepts.

5. Radiation has been shown to have little or no effect on thermoelectric elements under most conditions. However, other solid-state devices which have highly ordered crystalline structures are affected. More precise radiation knowledge is thus required to allow proper design to account for such damage and not cause overdesign of the devices. Except for photoelectricity, no other solid-state device can be considered operational for space use (even though a radio isotope powered thermoelectric generator has operated relatively successfully in earth orbit for over a year).

6. NASA and the Air Force both supply present radiation data.

7. Not applicable.

8. Future Air Force data requirements in this area will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameter: Radiation belts.

2. Available data being used are based on observations on mathematical and statistical predictions based on these observations.

3. The present data are not quite adequate and consequently orbital shots are being utilized to obtain actual performance data in this environment.

4. Solar cell flight vehicle power systems require these data.

5. Data are used to determine how much degradation of solar cell output is experienced versus time in orbit based on laboratory testing using particle accelerators. This is true for both design and potentially operational systems. Unknowns in this area may result in over design of vehicle power systems by as much as 50% in size or weight.

6. Data are provided by NASA experiments, Air Force radiation experiments and calculations and some Navy transit satellites.

7. A coordinating agency would be desirable.

8. Requirements will increase.

Source: ASD (Research and Engineering Branch, Programs Division, Plans and Operations Office).

1. Parameter: Radiation belts.

2. Data are observations from experiments and predictions.

3. Data are adequate for preliminary investigations. However, they are of questionable adequacy for detailed design and environment simulation.

4. Data are needed for advanced aerospace systems planning objectives.

5. Radiation is a hazard for manned space flight and is considered in applied research efforts in crew station and crew escape areas. Effort is not related to a specific USAF system.

6. Data are obtained from reports of various agencies, e.g., NASA, ASD, American Astronautical Society, Radiation Effects Information Center.

7. It is considered highly desirable for a USAF agency to collect, update and distribute data periodically, such that project engineers would know they are using best and latest available data.

8. Requirements will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameter: Radiation belts.

2. Data are obtained from probes into these areas.

3. Data are adequate, since most materials are inside space vehicle and subject to radiation from nuclear reactor rather than radiation belts. Advanced electrostatic generators that operate in the vacuum of space will be affected by charged particles; however, the data available should be sufficient.

4. Electrostatic generator power supplies for electric propulsion require these data.

5. Design of electrostatic generators that operate on a high electric field principle will attract the charged particles of the radiation belt. The effect of the charged particles on the field strength of the generator will determine the success or failure of electrostatic generators.

6. ASTIA provides these data.

7. Not necessary.

8. Not applicable.

Source: ASD (ASRMFP-1), Dynamic Energy Conversion Section.

1. Parameter: Ultraviolet radiation.

2. Moon's curves on solar radiation are currently being used. They are primarily based upon observation.

3. Data are accurate relative to design analysis.

4. Data are required for design of solar energy collection systems.

5. Tests indicate that plastic film reflectors will be degraded by long-term ultraviolet radiation.

6. Not applicable.

7. Not applicable.

8. No change.

Source: ASD (ASRMDS-2), Configuration Research Section.

1. Parameters: Cosmic radiation, other planetary atmospheres, corpuscular radiation, X-rays, ultraviolet radiation, solar wind, solar radiation pressure, solar flares, solar magnetic fields, radiation belts, electron density, meteoroid, micrometeoroid impact and flux parameters, temeprature, pressure density, chemical constituents, and electric fields of the lower atmosphere.

2. We are using data based on observation, prediction, and extrapolation.

3. Observation data are very scarce and appear to provide only a tentative description. In some cases a parameter may vary 2 to 3 orders of magnitude from prediction to observation.

4. All aerospace structures require some of these data.

5. Data are required to develop design information. The degree of criticality is uncertain and will probably depend upon greater knowledge of the parameters and their influence upon structural configurations.

6. Various government agencies and industry provide data.

7. Even though the USAF is involved in this data gathering, the information comes from too many different sources and lacks completeness. A central source would be desirable.

8. Data requirements will increase with expanded aerospace requirements.

Source: ESD (496L System Program Office).

1. Parameter: Corpuscular radiation.

2. No data on this parameter are presently used, although limited data are available.

3. No evaluation of available data has been made.

4. The 496L (Space Track) System could profitably use the data.

5. The radiation photons (or particles) of energy, i.e., wave energy packets, induce electric charges on orbital vehicles giving rise to the phenomena known as electromagnetic drag. This drag affects the accurate computation of orbital elements and parameters used in the accurate tracking and identification of friendly or foreign orbiting vehicles. It is desired to have specific tabulated data for the effect of corpuscular radiation and electromagnetic drag on the orbital elements of space vehicles. Particularly it is desired to have data on corpuscular radiation orbital effect as a function of the time of day, altitude and position of earth in its orbit.

6. The National Bureau of Standards and AFCRL obtain and could provide some data.

7. The AWS should assist in forecasting the intensity of corpuscular radiation and should be the primary distributional agency for routine, operational use.

8. Requirements for this type of data will increase.

Source: ESD (496L System Program Office).

1. Parameter: Solar flares.

2. Both observations and predictions are currently used.

3. Adequacy of current data is fair.

4. The 496L (Space Track) System uses these data.

5. It is known that solar flares affect the upper atmospheric density and composition which in turn affects the accuracy of prediction of orbits. It is desired to have specific data on the direct effect of solar flares on atmospheric composition and density.

6. The National Bureau of Standards and AFCRL currently provide the data.

7. The AWS should have responsibility, develop capability for observing and predicting solar flares and disseminate the required data.

8. Requirements for these data will increase.

Source: ESD (Plans and Programs).

1. Parameter: Magnetic Storms.

2. Data presently used are observations and predictions based on statistics.

3. The adequacy of the data is fair.

4. Systems that require the data are 416L (SAGE), 465L (SAC Control System), 473L (AFC&C), 474L (BMEWS), 496L (SPADATS).

5. Data are required for system operations. HF links are susceptible to disruption during periods of magnetic storms.

6. The National Bureau of Standards provides the data.

7. AWS should develop a prediction capability and should be the primary distribution agency for routine, operational use.

8. Requirement for these data will increase.

Source: ESD (496L System Program Office).

1. Parameter: Solar radiation pressure.

2. To obtain some measure of the effect of radiation pressure, plots of the variation of perigee and apogee are made as a function of time of day.

3. This approach gives poor results.

4. The 496L (Space Track) System uses these data.

5. In addition to the build up of electric charges and resulting electromagnetic drag, the energy packets (photons) emitted from the sun possess sufficient momentum to directly change the orbit of vehicles in outer space by virtue of the energy exchange between the vehicle and photons. It is known that both the apogee and perigee are changed by solar radiation pressure. It is desired to have specific tabulated or plotted data on the effective orbit of space vehicles; that is radiation pressure as a function of time of day, altitude and position of earth in its orbit.

6. NASA currently supplies the data.

7. AWS should assist in establishing the capability to provide the desired data and be responsible for distribution of operational data.

8. Requirements for these data will increase.

Meteoroid Environment. Meteoroids are solid material in interplanetary space that are too small to be detected visually (from earth) as individual particles. They range in size from about 10^{-4} centimeters to several meters. Meteoroids of a radius less than 10^{-1} centimeters are usually classed as meteoritic dust or micrometeoroids.

Very little direct data on the meteoroid environment have been collected. For example, an accurate estimate of the meteoroid flux in space cannot be made (Reference 7). Even in the vicinity of earth, where information has been obtained by direct and indirect observations, the derived flux values differ by several orders of magnitude, depending on assumptions made by the various investigators. The actual velocities can be given. Little is known of the mass distribution of meteoroids. Only recently have estimates been made based on direct observations.

The meteoroid environment is of particular concern to the Air Force because of its potential effect on space vehicles. Principal effects are the puncture of a space vehicle and erosion or pitting of sensitive optical and thermal control surfaces. Meteoroids which constitute a puncture hazard to space vehicles are those which possess sufficient relative momenta to penetrate the structure of the vehicle and which are present in sufficient numbers to have high probability of encounter during a mission. In the extreme case, penetration could destroy instrumentation within the vehicle or harm occupants directly. The more probable effect of a penetrating meteoroid, however, would be damage to man or equipment by upsetting environmental control of the vehicle.

At the present time there is about a 200-fold uncertainty in the meteoroid mass associated with a given flux of meteoroids large enough to penetrate an unshielded space vehicle. This leads to a six-fold uncertainty in the required shield thickness for adequate degrees of protection. Current shielding designs, of course, are based on the pessismistic side, with the probable result of overshielding and reduced payload.

Although the effects of a large meteoroid collision with a space vehicle would be catastrophic, the slow erosion of sensitive surfaces by meteoritic dust would be disastrous, even though less spectacular. Estimates of the meteoroid flux based on very scanty data vary by as much as three orders of magnitude, but it appears that the magnitude of the flux is inversely proportional to the mass of the particles. Data from some satellites and rockets indicate that there may be a high concentration of interplanetary dust near the earth and various

possibilities are postulated to account for such a concentration: the earth's gravitational attraction, electrostatic explosion of particles caught in the radiation belts, capture by high charge, high drag processes in the radiation belts and direct sporadic lunar contributions. Whether there is a near-earth concentration or not must be definitely proved, but experimental evidence has shown that meteoritic material varies in both time and space. The degree of variation is unknown. The Air Force, NASA, the US Navy and civilian companies are currently engaged in laboratory and space experiments in the meteoroid eivironment, its effect on space vehicles and methods to reduce the hazards. However, the actual environment must be known through direct observations and analysis of the data collected.

An adequate knowledge of the meteoroid environment conceivably could result in reduction of current shielding requirements by as much as five-sixths. In view of the importance of these phenomena to Air Force space plans, it appears that the Air Force should take a leading part in designing and conducting the necessary programs to ascertain the meteoroid environment as soon as possible. It will undoubtedly take many years to acquire a detailed understanding or even description of the meteoroid hazard. Data that are collected should be placed in the hands of a single controlling agency. Air Force interest in this problem will continue at a high level throughout the foreseeable future.

Specific Requirements: Meteoroids.

Source: ASD (ASRMDS-3), Structural Loads Section

1. Parameters: The following environmental parameters are required in connection with manned space flight.

   a. Meteoritic density and speed.

   b. Radiation.

   c. Cosmic dust.

   d. Magnetic fields.

2. Data used are predicted.

3. Data are inadequate.

4. These data are not required for any particular existing system analysis as such, but for the development of structural design criteria for future USAF flight systems.

5. Not applicable.

6. Not applicable.

7. Not applicable.

8. Future USAF data requirement will increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameter: Cosmic dust.

2. No data are currently used.

3. Not applicable.

4. Electrostatic generator systems require the data.

5. Data are needed to determine the operation of the electrostatic generator as cosmic dust comes in contact with the high electric fields of the generator. The effect of cosmic dust on electric fields could determine the success or failure of electrostatic machine in space environments.

6. No agency supplies this type of data.

7. Since this will be a problem throughout space a joint agency between NASA and the Air Force would be desirable.

8. Requirement will increase.

Source: ASD (ASRMFP-1), Dynamic Energy Conversion Section.

1. Parameter: Meteorites.

2. Current data are based upon observations and predictions.

3. Data are currently inadequate as meteorite particles in the size which could cause the worst damage have not been measured.

4. Data are required for the design of solar energy collection systems.

5. Meteorites of microscopic size will degrade the surface of solar reflectors and reduce overall performance.

6. Unknown.

7. Not applicable.

8. Future requirements will decrease as specific reflector space tests are to be flown to investigate the effect of meteorites on solar reflector surfaces.

Source: ASD (ASRMFP-1), Dynamic Energy Conversion Section.

1. Parameter: Meteorites.

2. Observations, predictions, and statistical data are currently used.

3. The data available for predicting meteorite frequency, mass velocity, and penetration are for the most part inadequate. Little of the information available is backed up by test data. The test data which are available on penetration has, for the most part, been at velocities much lower than those which will actually be encountered. Recent tests nearer the lower meteorite velocities indicate that existing meteorite penetration theories are not holding up.

4. All power systems will require these data.

5. These data are necessary in designing penetration protection for vulnerable areas of power systems. In dynamic systems where fluid carrying members are vulnerable, a puncture in the member would cause the system to fail.

6. Air Force and NASA supply data used at this time.

7. The Air Force currently has a high velocity gun which will fire an eleven mg particle at 50,000 ft/sec which is at the lower meteorite velocity range. Indications are that this gun can accelerate the same mass particle up to velocities of 102,000 ft/sec. This gun should definitely be developed to reach higher velocities; however, it would probably not require a separate USAF organic capability to acquire the data.

8. Future requirements will definitely increase.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameter: Meteorites.

2. Present data result mainly from predictions and statistics.

3. Data are incomplete.

4. Subsystem concepts which require these data are theromelectric and other solid state conversion concepts.

5. Meteorite and micrometeorite data are required for determination of surface deterioration with respect to earth orbital distance and, eventually, with respect to interplanetary flights. Such data are vital to life, initial power-weight requirements, reliability, and confidence factor. No systems are now operational.

6. NASA and USAF supply present data.

7. An Air Force capability to provide such data is desirable.

8. Future Air Force data requirements will increase.

Source: ESD (496L System Program Office).

1. Parameter: Cosmic dust.

2. Data of this type are not currently used, but some data could be made available through research agencies.

3. Adequacy of research data has not been evaluated.

4. The 496L (Space Track) System could profitably use these data.

5. The existence of cosmic dust in the neighborhood of the orbits of space vehicles poses the problem of possible interaction with the vehicle and this would affect the tracking and prediction accuracies in the calculation of orbital elements. It is desired to have data on probable locations of cosmic dust and its concentrations.

6. The Air Force through research and development agencies (AFCRL and universities) could provide some information.

7. The USAF should assist in establishing a capability to provide the desired data.

8. Requirements for this type of data will increase.

Source: ESD (496L System Program Office).

1. Parameter: Meteorites.

2. Both observations and predictions are currently used.

3. Adequacy of present data is fair.

4. The 496L (Space Track) System requires this type of data.

5. The existence of meteorites poses several problems. First there is the possibility of direct collision with orbiting vehicles which would affect and change the orbits by virtue of the energy exchange. This would certainly affect the tracking and prediction accuracy in the calculation of orbital elements. Second, meteorites must be programed out of present computer programs to decrease or eliminate false returns. Third, when meteorites enter the atmosphere, it is possible to detect the ionized trail. This produces false returns. It is desired to have prediction tables on both trajectories and expected life of meteorites.

6. The National Observatory, Smithsonian Institution currently provides data.

7. The USAF should assist in establishing a capability to obtain and distribute the desired data.

8. The requirement for this type of data will increase.

Source: SSD (SSZDP), 622A Program Directorate.

1. Parameters: Meteorites and cosmic dust.

2. Statistical data based on observations from past flights are currently being used.

3. Data are adequate for the present.

4. Program 622A uses these data.

5. Data are used to design protective structure and materials for space vehicles. Problem is not critical to Program 622A because structures are overdesigned.

6. AFCRL provides the data.

7. Not applicable.

8. Future USAF data collection efforts should remain at a constant level to provide more precise data for extremely light weight structures.

Planetary Atmospheres (Reference 8) (Lunar Atmosphere Included). The heavenly bodies of greatest immediate interest in our National Space Program are, of course, those which come nearest to earth, our moon, Mars and Venus. The atmospheres of these bodies are discussed here individually. The environmental considerations for each "planet" will pose different problems in design, engineering, and operational concepts for manned or unmanned vehicles. The atmospheres of the remaining planets of the solar systems are discussed collectively in the final paragraphs of this action.

Moon. Since the surface pressure on the moon is of the order of 10^{-13} earth atmospheres (from occulation observations), the lunar atmosphere is a virtual vacuum. The composition of what atmosphere is there is unsolved. Some of the gases that may be found are SO_2, CO_2, H_2O, and some of the rare gases such as argon, helium, xenon, krypton, radon, and neon. These probably originate in the interior and are continually expelled by slight changes in the lunar surface. Except for possible heavier gas accumulation the atmosphere must be transient; the velocities of the molecules are greater than the escape velocity.

This essential lack of an atmosphere gives rise to very great temperature differences between lunar day and night. Radiometric observations of the lunar surface temperature give a maximum of about 130°C and an unreliable minimum of about -150°C. Also, failing a protective atmosphere, there is no attenuation of cosmic and solar radiation. Should solar radiation prove to be a serious problem there are numerous locations, in shadows most of the time, which could be selected as long term sites for expeditions. Trapped particle radiation should present no problem since no lunar magnetic field has been detected. Because of the moon's lesser gravitational force, the total influx of solid particles on the lunar surface should be less than that experienced by earth's atmosphere. The damaging effect of meteors on the moon's surface would be much greater than on earth's due to lack of atmospheric protection. Space estimates of meteoroids vary widely between theoretical and measured values; methods of calculation are crude to date. Rareness of lunar collisions with great meteoroids is such that we have no predictable probability of their occurrence.

Mars. The known conditions on Mars are the least hostile towards life of any body in the solar system (except earth), but for most purposes it is a forbidding world with stringent requirements for the operations of men and equipment. From visual, photographic, and theoretical evidence and considerations, the existence of an atmosphere on Mars is unquestioned, but knowledge of its properties is

limited. The Mars' atmosphere is expected to provide more drag on entering bodies than that of the earth and is probably very turbulent due to strong convection currents. CO_2 is the only gas positively identified. Most authors assume molecular nitrogen and argon are the major atmospheric components and it is generally conceded that water vapor, along with traces of other gases are present. The surface pressure is estimated at approximately 85 mb, but above 31 km the pressure is greater than earth's at the same altitudes. Wind speeds are estimated by observing clouds moving across the planet. Speeds average near 20 mph; 70 mph drifts have been observed.

Radiometric measurements indicate a range of surface temperatures from -70°C to 30°C. Mars is thought to have a small magnetic field compared to the earth. From this conclusion and because of the great distance from the sun, trapped particle radiation is not likely to be of such high intensity as it is near the earth. Various clouds occur -- some high cirrus, others probably dust from the surface. Dust clouds can cover large portions of the planet.

<u>Venus</u>. Dense clouds completely obscure the surface of Venus so that direct investigation of temperature, composition, and other parameters of the lower atmosphere and surface are not possible. Thus, only the portions of the atmosphere above the clouds are accessible to a spectroscopic investigation. From these investigations CO_2 has been the only gas positively identified. It is generally agreed that some nitrogen and at least traces of argon and other gases may be present. The conditions at the surface are not reliably known. It is generally supposed that the surface is very warm by earth's standards -- but this is completely speculative. Estimates from radiation measured at centimeter wave lengths (presently thought to represent the surface temperature) find the values in the 600°K neighborhood. IR measurements suggest an effective radiative temperature of about 233°K, but it appears that the cloud top layer is the source. Students of Venus imagine the surface to be a desert -- hot, arid, calm and overcast. A model atmosphere of Menzel and De vauconleurs is the most acceptable at present; they give a surface temperature of 580°K, and a pressure of 2.5 atmospheres (uncertainty factor of 2 or 3). In the model they incorporate microwave, radiometric, spectroscopic, and occulation data.

The intensity of electromagnetic and particle radiation from the sun is about two times that received at earth. This is an extremely important point in the physics of the upper atmosphere and for possible belts of trapped radiation. If Venus possesses as strong a magnetic field as theory has it (stronger than the earth's), then it is quite likely there is some structure of intense radiation surrounding the planet.

Remaining Planets of Our Solar System. Mercury has a very low escape velocity suggesting it should have very little, if any, atmosphere. Jupiter's atmosphere, as partially revealed by spectroscopic data, contains methane in gaseous form and ammonia possibly in crystal form. Star occulations have led to the conclusion molecular hydrogen and helium are the main constituents. Saturn's atmosphere also is believed to have hydrogen, helium, methane, and ammonia. Uranus' spectrum shows dark bands of methane as well as a broad absorption band in near infrared that has been attributed to molecular hydrogen. For Neptune, spectroscopic investigations indicate methane in the atmosphere. For Pluto, no atmosphere has been detected.

Data for these planetary atmospheres will be needed for studies that would necessarily be part of the planning to place manned or unmanned vehicles upon their surfaces and retrieve them. The requirements are for data on atmospheric compositions, densities, pressures, temperatures, radiation levels, etc. A quantitative knowledge of these paramaters is absolutely essential in determining the feasibility of manned landings and return.

There is very little known about the planetary atmospheres to date. Many probes and instrument packages passing near or landing on these planets will be needed to ascertain their natural environments. Presently available information from radiometric measurements, visual observations, spectroscopic measurements, microwave work, occulation observations, and theoretical predictions provide preliminary knowledge but this is incomplete and inadequate.

USAF data requirements will increase. Once the feasibility of exploring various planets is established (this in itself will require a tremendous national effort) additional precise environmental data will be needed for the design of structures, instrumentation, and the artificial environmental equipment that will be required.

In the future, the Air Force must have an access to the available data. The envisaged great amount of data to be collected and processed and the variety of parameters to be measured make premature any statements as to what agency will or should handle or process the data. It is certain that many agencies will be interested in the data and some facile retrieval method must be available. It is reasonable to assume the Air Force will conduct many of the experiments for data primarily of importance to its mission and secondarily to the scientific community.

Specific Requirements: Planetary Atmospheres.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations).

1. Parameter: Other planetary environmental conditions.

2. Present data result mainly from predictions.

3. Data are very incomplete.

4. The general subsystem concept which requires such data is the thermoelectric (high and low temperature) conversion concept.

5. Such data are required to allow for design and environmental experimentation of various thermoelectric concepts as would be required for flight vehicle power around and extraterrestrial power on other planets. Such data are critical for all design characteristics. No systems are now operational.

6. NASA supplies most present data.

7. An Air Force capability to provide such data is desirable.

8. Future Air Force data requirements will increase.

Source: ASD (ASRMFE-1), Flight Environment Technology Section.

1. Parameter: All cislunar environments.

2. Kind of Data: Mostly earth observations, some probe shot data. Also a lot of "guesstimation" from various sources.

3. Adequacy: Realistic trade offs for long duration space system designs cannot be made with presently available information. Conceptual designs can be studied. We must have sufficient data to be able to predict the location, magnitude and variation of meteoroids, solar flare and Van Allen radiation for example.

4. Systems: Near-earth satellites, far-earth satellites, and lunar vehicles, manned or unmanned.

5. System Use: All information is critical because too little is known. Designers must resort to large overdesign and large safety factors to get reasonable reliability.

6. Sources: Primarily the Geophysics Research Directorate, AFCRL. We also have direct contact with the Air Force or NASA agencies who send up probe vehicles. Remainder of information comes through literature review.

7. Organic Capability: We already have more focal points for such data, than sources. The main need is for generating, not collecting, at present.

8. Future Data Requirements: Will definitely increase. Basic feasibility of systems already hangs on accuracy of environmental data, primarily on meteoroids and corpuscular radiation levels. One can only go so far parametrically; then accurate values have to be assigned to environment.

Additional Comments.

1. If anything distinguishes military vehicles from purely scientific vehicles, it is that military vehicles must be able to perform missions regardless of prevailing weather. Achieving this capability will require protection of men and equipment from such environments as solar flare and Van Allen radiation. Knowledge of actual environmental conditions will determine in many cases whether a conceptual protection scheme is feasible. The relation between environmental support services and flight vehicles of the future can be generally stated as follows:

a. The natural environment must be studied, probed, and mapped to determine:

(1) The average levels of environmental elements as a function of position in aerospace.

(2) The patterns of variation of these elements in time and position.

b. Once these patterns have been established with reasonable accuracy, further studies must be made to find which of these variations are predictable, how much in advance, and with what accuracy?

c. The advance warning capability will dictate:

(1) Which systems must have continuous or "built-in" environmental protection.

(2) Which systems will need only intermittent protection.

2. The main point of the above is that systems must be built to continually withstand environments that are constant or unpredictable; systems may be able to use intermittent-duty protection from predictable environments. Intermittent-duty is desirable where power or components could be directed to other uses when not required for protection. Environments can be useful. A particularly energetic environment might be used to advantage when its existence is accurately defined.

3. The Geophysics Research Directorate, AFCRL, is primarily responsible for Air Force research described in paragraph 1a. Presumably, the Air Force Climatic Center and Air Weather Service would perform the studies described under 1b. The area of translating results of these studies into system design parameters is a somewhat questionable area, where interfaces are not clearly defined.

Source: ESD (496L System Program Office).

1. Parameter: Stellar radio emission.

2. Both observations and predictions are currently used.

3. The adequacy of current data is fair.

4. The 496L (Space Track) System requires these data.

5. The statistical properties of stellar radio emission are important in that they determine the amount of noise introduced into radar systems. It is known that the probability of detection decreases as the signal to noise ratio decreases. Further an increase in noise increases the false alarm rate. It is desired to have accurate statistical description (e.g. power spectral density or auto correlation functions) in order to be able to design systems which will minimize the noise effect in the Wiener-Hopf optimal filter sense or any other suitable related criterion. It would also be very useful to have data on the expected directions of the stellar emissions in order to determine general system configuration. A specific design consideration is the location of sensors to minimize the effect of stellar emissions.

6. The National Bureau of Standards and AFCRL currently provide data.

7. USAF should assist in improving the capability of obtaining the desired data and in providing for distribution.

8. Requirements for these data will increase.

Source: SSD (SSTRE) Spacecraft Technology Division

1. Parameter: Cislunar magnetic fields.

2. Statistical data and predictions based on earlier flights are used at present.

3. Data are inadequate in that it is incomplete and of limited coverage.

4. Data are required for design of space vehicle borne computers.

5. Data will be used in computer design particularly on the use of magnetized elements, both logic and storage, in a wide variety of space missions, i.e., orbital, translunar, ballistic, etc.

6. Unknown.

7. Not applicable.

8. Requirements for these data will increase.

SECTION 4

Group III Parameters

New environmental support requirements in the lower atmosphere continue to appear. As military technology advances, weather service of the climatological and special study type has extended into meteorological areas outside the elementary weather and climatic parameters associated with "conventional" air and ground operations. An increasing number of development, test, and operations problems require knowledge of fine-scale features of the atmosphere. Several families of problems are appearing.

Diffusion. Many new fuels and oxidizers for rockets contain materials which, in sufficient concentration, are toxic to human beings. After toxic gases are released in the atmosphere, their concentration or dispersion are functions of the micrometeorological variables, wind, temperature profile near the ground, etc. Thus micrometeorological events may determine whether or not a safety hazard exists or will develop, for example, from a fuel spill. A similar problem may arise from the release of radioactive effluents from any nuclear facility; dispersion and measures of concentration are functions of micrometeorological variables, among other factors. Similarly, the effectiveness of nonlethal biological/chemical agents may in large measure be dependent on micrometeorological variables.

Special or Local Conditions. Some problems involve not only properties of the free air, but also conditions induced at the air-earth interface which can be indexed by atmospheric conditions. The condition of foliage (wet or dry), induced by a combination of meteorological and biological conditions, can be of prime importance in the use of chemical warfare materials. Many communication and radar problems require the analysis and evaluation of electromagnetic radiation propagation through the troposphere. Often, peak wind and ice loading must be specified for remote radar antennae locations for which little or no data exist. Data must be collected and/or problem solving methods developed to provide usable answers to such problems.

Wind Requirements for Missiles and Ballistics. There are numerous requirements for specifying structure of the wind field in finer detail than has heretofore been necessary. Wind variability is now established as the largest remaining error in artillery. Extensive work on it has been required for tank and anti-aircraft fire control systems. For missiles, detailed information on variability or turbulent structure is necessary for initial design, to determine

accumulated stress and fatigue between missile setup and launch, for aiming unguided missiles and for design of guidance systems, and for launching itself. Of particular importance are wind and wind shear observations and statistical measures in great detail from the earth's surface to 60,000 feet.

Index of Refraction. This is a controlling environmental parameter in systems employing microwave radiation. Crucial features of this parameter require specification of meteorological parameters with far more precision than has been possible from observations designed for weather analysis, forecasting, and aircraft operation. As early as 1955 limitations in data commonly available made it impractical to make the desired evaluation of the performance of defensive radar nets. A requirement for work (Project LAYDET) to define problems and improve capabilities in this area currently exists. Radar problems with "radio holes" were serious enough in the past, but are becoming more so with doppler and interferometer techniques now coming into use. Problems listed in this section illustrate that meteorological support requirements are increasing not only in connection with penetration into space, but also multiplying in the area of conventional weather support. New systems generate requirements for precise and detailed information on almost any manifestation of the atmospheric environment. Pressing military requirements for the information do not permit a "research" treatment if there is any alternative.

Generally, such requirements must be met by application of knowledge currently available from meteorology and related sciences. This approach usually is not completely satisfactory, since many of the hypotheses used are in error, while the lack of the desired environmental data prevents adequate adjustments. The necessary equipment or instruments to obtain the data to meet most of the requirements imposed by newer, more complex systems exists or is being developed and some data have been obtained in checking out newly developed instruments. For the most part, however, no programs exist to gather the data on a scale necessary to meet future requirements expeditiously. Environmental support must be kept concurrent with requirements of the advanced systems in the conceptual stages. To provide the necessary environmental design criteria the collection and analysis of the pertinent data must have been accomplished far in advance. It is not possible to collect two or three years of data in a few days or months. A major requirement of the meteorological support agencies is sufficient data to answer the environmental data needs in the problem areas so briefly mentioned.

Specific Requirements: Miscellaneous.

Source: BSD (BSRVT-3), Ballistic Missile Re-entry Systems Office.

1. Parameters: Atmospheric water vapor content and aerosols above 20,000 feet.

2. At the present time gross predictions based on average or expected conditions are used.

3. Actual observations are required.

4. The TRAP program requires these data.

5. The proper interpretation of measurements of radiation emitted by re-entry vehicles, as typified by the TRAP program, depends on a knowledge of atmospheric transmission at high altitudes in the re-entry areas and the atmospheric transmission in the infrared/optical ranges in turn depends on a knowledge of absorbing or scattering agents, mainly water vapor and aerosols. Corrections for atmospheric absorption and scattering must be made to the radiation measurements and these corrections are meaningful only to the extent to which the absorbing or scattering agents are known.

6. These data are not now normally supplied.

7. It is desirable that these data be supplied by instruments aboard the TRAP aircraft to the fullest extent possible.

8. Unknown.

Source: AFFTC, Chief, Flight Test Engineering Division.

1. Parameters: Atmospheric temperature, pressure, humidity, and wind direction and velocity at altitudes from sea level to 100,000 feet.

2. Data from periodic meteorological observations are used on many occasions during analysis of aerodynamic flight tests.

3. Data now available are inadequate for most test work because of inaccuracy. Data from airborne instruments or range instrumentation are far more accurate in many instances. However, meteorological data now used are better than nothing.

4. These data are required for tests of almost all aircraft. Specific examples are: B-52H, HC-1B, F-111 and B-70.

5. Some of the parameters (wind direction and velocity) are required on almost all performance tests of aircraft, and the others are always used as a backup for, and check on, the airborne instrumentation. These parameters are used in data reduction of performance tests and stability and control test. Lack of this data is sometimes critical for the test results. The quality of test results and rapidity of test completion would be improved with more accurate data. Desired measurement accuracy of the parameters is:

PARAMETER	MAXIMUM RMS ERROR
Temperature	$1/2^{\circ}C$
Wind Direction	3°
Wind Velocity	1 Knot
Pressure	.005 In. Hg.
Humidity (H_2O Partial Pressure)	.005 In. Hg.

6. Air Weather Service provides this data and, in addition, surface meteorological data is obtained by the local test support organizations.

7. Not applicable.

8. Future USAF data requirements will remain approximately constant during the next five years.

Source: APGC (PGOPL), Plans and Operations.

1. Parameter: Diffusion properties on the lower atmosphere.

2. Data are observed.

3. Data presently collected are inadequate.

4. Bacteriological and chemical warfare tests require this type of data. Later the possibility of missile fuel spills will generate a requirement for this parameter.

5. Current and future tests of BW and CW require a knowledge of the detailed structure of the lower atmosphere for the success of the tests. As larger missiles with toxic fuels are tested the diffusion properties of the lower atmosphere must be known for proper safety.

6. Detachment 10, 4th Weather Group, Air Weather Service, provides the data.

7. Not applicable.

8. Because of increased BW/CW testing and because of proposed missile launches the requirements will increase.

Source: APGC (PGOPL), Plans and Operations.

1. Parameter: Index of refraction.

2. Currently data are derived from observed temperature, humidity and pressure.

3. Currently, data are adequate but for future accuracy requirements data will be inadequate.

4. The EGTR up-dating requires these data for future use for space positioning of radar and for telemetry links.

5. The effect of a variable index of refraction field on bending of electromagnetic radiation causes errors in radar and difficulty in microwave transmission. At present the data is being used to study their effects. In the future this data will be the limiting factors in radar accuracy and will be necessary for telemetry success.

6. Detachment 10, 4th Weather Group, Air Weather Service, with civilian contractors provides this data.

7. Due to the complexity of the tests involved, the present arrangement of using civilian contractors is the optimum solution.

8. Due to more advanced radar and telemetry the requirement will increase rapidly.

Source: ESD (Plans and Programs).

1. Parameter: Index of refraction.

2. Both observed and predicted data are used.

3. Concerning the adequacy of available data there are two problems associated with the measurements. The first problem deals with instrumentation. Current techniques involve balloon borne refractometers or variations thereof. The track of the refractometer is different from the ray path of the radar and, further, the instrument is launched usually at a different time from operation of the position-determing radar sensor. Consequently, there is a need to refine instrumentation techniques to give more valid refraction data for the time and ray path involved. Secondly, there is a need to determine how to use the data from the refractometer. Current investigations show that sometimes index of refraction and range error between two fixed points correlates positively, and sometimes negatively. One must determine for a given time which algebraic sign of correlation is involved.

4. Systems that require the data are 412L (Air Weapons Control), 416L (SAGE and BUIC), 466L (ELMINT), 474L (BMEWS), 496L (SPADATS).

5. Index of refraction is used in the operation of the above-named systems. It is desired to reduce the residual error due to ray path deviations for radar sensors to an acceptable minimum for all the above systems. 466L must know the source of electromagnetic radiations and must know beforehand when long range ducting will occur.

6. AWS provides the data at test ranges. Air Force is involved in the HIRAN program. NBS provides CRPL reports.

7. AWS should provide distribution of these data for routine, operational purposes. Further R&D should remain with established R&D agencies.

8. Need for the data will increase.

Source: ESD (Plans and Programs).

1. Parameters: Lightning strikes and lightning discharges (Sferics).

2. Predictions of lightning strikes and observations of strike occurrences in the form of sferics reports are currently used.

3. Sferics data are satisfactory. Forecasts are inadequate in that they can only indicate areas of occurrence with some degree of confidence. No capability exists to give a "yes or no" forecast for a particular site.

4. Systems that require the data are 425L (NORAD), 465L (SAC Control), 466L (ELMINT), 477L (NUDETS), 480L (Air Communications System).

5. Data are needed for antenna design and to lessen missile vulnerability during refueling operations. Also background noise and spurious signals in LF operations can be anticipated and the effects lessened by corrective measures if the occurrence of strikes in the vicinity can be known in advance.

6. Data are presently supplied by the AWS.

7. It would be desirable to increase the reliability of the AWS to predict lightning strikes in the vicinity of antennas and for fueling operations of both missiles and aircraft.

8. Requirements for this capability will increase.

Source: AFSWC (SWX), Staff Meteorologist.

1. Parameter: Electrical fields in the lower atmosphere.

2. We are not yet using these data.

3. The data we are using are entirely inadequate, in that fueling operations are suspended when the wind is forecast to exceed 25 knots with no measure or even estimate of the electrostatic charge.

4. All systems using highly flammable material require this type of information.

5. Data will be used for fueling operations. Dry climate makes adequate grounding difficult and permits dangerously high electrostatic charges. When spark discharges become possible, fueling should be suspended. Obviously, a forecast of the necessity for such suspension will permit more efficient operations.

6. Observations taken by Organization 7243 of Sandia Corporation are available by phone. To date, they have not been used.

7. If investigation shows observations taken at or very near the weather station are representative of the site where flammable material is stored and transferred, then observations taken by AWS personnel would be worthwhile service. In any case, forecasts should be prepared since critical conditions depend on winds, lithometeors, moisture, stability and perhaps other meteorological variables.

8. Requirements will surely increase as better fuels are developed.

Source: SSD (SSZDP), 622A Program Directorate.

1. Parameter: Earth's magnetic field.

2. Observational and theoretical data are currently being used.

3. For the present, available data meet requirements.

4. Data are used for a guidance system input for Program 622A vehicles.

5. The magnetic field is used as an angular reference. If angular reference is off more than 5-10 degrees, the re-entry dispersion can be affected.

6. Many agencies contribute to the data available, such as AFCRL, U.S. Hydrographic Office, The Smithsonian, National Geographic expeditions and agencies of other countries.

7. AFCRL is already active in this field.

8. After initial mapping, future USAF data requirements should remain constant to observe magnetic field shifts.

Source: ASD (Chief, Research and Engineering Branch, Programs Division, Plans and Operations Office).

1. Parameter: Ground winds.

2. The ground wind data being used are limited observational data.

3. The data are adequate for preliminary investigations of the dynamic response of vertically launched vehicles between the time of gantry removal and vehicle lift-off. The data are inadequate for detailed investigation of ground wind induced dynamic loads for design purposes, since there is a lack of definition of wind velocity gradients and directions up to 300 foot altitudes as well as power spectral densities defining frequency content of these winds at existing and various possible launching sites.

4. Systems which require these data include any of the long slender body vehicles and all vehicles with significant winged payloads.

5. The ground wind condition is a significant condition for designing the base of the vehicle as well as the support structure. Further, since this condition limits the number of days the vehicle can be launched, and poses a significant fatigue problem for winged payload vehicles, the lack of knowledge of the actual wind structure requires restricting safety factors.

6. The Air Force Cambridge Research Laboratories (OAR) has been one source of information, however, all agencies with launch sites are potential sources.

7. Not applicable.

8. It is anticipated that future USAF data requirements regarding definition of ground winds will increase.

Source: ESD (Plans and Programs).

1. Parameter: Wind variations with altitude.

2. Data presently used consist of observed and forecast wind and wind shears, including turbulence, eddy currents and diffusion.

3. Data are not adequate for small scale eddies on an operational basis. It is fair for medium scale observations and fair for diffusion for specific sites at specific times, but should be extended to cover other systems.

4. Systems that require the data are 412L (Air Weapons Control System), 416L (SAGE), 465L (SAC Control System), 425L (NORAD).

5. Winds are required for intercept vectors on 416L. Wind shear and wind data are required for go-no go determination of launching of ballistic missiles, or status reporting. Diffusion data are required for personnel safety when exposed to toxic fumes resulting from fuel tank leakage and when nuclear debris is involved. Entrances and ventilators of 425L are not under continuous filtration, so warning is required.

6. AWS should provide medium scale observation and predictions. AWS and AFCRL should provide micro scale determinations for toxic fume diffusion.

7. It would be desirable to establish an organic USAF capability through AWS to provide the data in conjunction with specific systems.

8. Requirements for these data will increase.

Source: APGC (PGOPL), Plans and Operations.

1. Parameter: Ballistic winds.

2. Data are mostly observed with some forecasts.

3. Data borders on the inadequate due to lack of accuracy.

4. Unguided missile launches require this type of data.

5. Wind data are collected before launch by means of single theodolite pibal observations. These data determine the impact prediction and are mandatory for the safety of the mission.

6. Data are provided by Detachment 10, 4th Weather Group.

7. Detachment 10 is an Air Force agency.

8. Increase in the number, size, and variety of probes will increase the accuracy requirement.

Source: ASD (DASP), Directorate of Advanced Systems Planning.

1. Parameters: The requirement is for techniques -- one to predict or measure meteorological wind and temperature gradients over targets where BW/CW munitions will be used.

2. Statistical data, observations and prediction techniques are needed.

3. Observations, prediction techniques and diffusion theory are inadequate to fully describe the dispersion of BW/CW agents with sufficient accuracy.

4. Proposed BW/CW munitions systems require such information.

5. Temperature and wind gradients, within the first few hundred feet from the ground over target areas, can substantially affect not only the performance of a BW/CW system, but the mode of agent release as well. Agents released above temperature inversions by spray techniques may never reach the ground. Inaccurate knowledge of wind conditions may cause agents to be dispersed among friendly forces. Meteorological conditions will affect the quantity and kind of agent used as well as the time of the operation, i.e., ultraviolet radiation from sunlight will destroy many BW agents. In short, the planning, conduction and success of a BW/CW mission will depend considerably on meteorological conditions.

6. Normally, the AWS would provide these data.

7. Not applicable.

8. Requirements will increase as we develop the capability to employ these agents.

Source: AFSWC (SWX), Staff Meteorologist.

1. Parameter: Air density forecasts.

2. Forecasts used are based on radiosonde reports. At the levels required, persistense appears to be the best prediction.

3. For the experiments we have supported to date, our calculations are adequate.

4. Automatic heat-seeking guidance systems require this information.

5. Data are used in relating the position of the heat center and the shape of jet-plumes to air density, or altitude. This will affect the design of heat-seeking guidance systems to be used at high altitudes.

6. AWS furnishes this information.

7. Not applicable.

8. USAF data requirements have increased and are expected to continue to increase. Present data are probably adequate to 100,000 feet, but AFSWC is interested in density information to 400,000 feet.

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